

CLAIMS

1. An optical cap structure for semiconductor device, said structure comprising:

a cap body having an opening;

5 an optical window made of glass plate sealed with said cap body to cover said opening so that an optical beam transmits through said optical window; and

10 a sealing member for sealing said optical window with said metal cap, said sealing member including a bismuth low-melting point glass containing no lead, an intermediate metal layer attached to said metal cap body, said intermediate metal layer being a metal capable of causing an eutectic reaction with respect to Bi contained  
15 in said low-melting point glass, and an eutectic alloy layer thus formed between said low-melting point glass and said intermediate metal layer.

2. An optical cap structure as set forth in claim 1, wherein said intermediate metal is a plated gold, so  
20 that said optical window is sealed with the cap body by means of the eutectic alloy of Bi contained in said low-melting point glass and Au of the intermediate metal.

3. An optical cap structure as set forth in claim 1, wherein said intermediate metal is a plated palladium,  
25 so that said optical window is sealed with the cap body by means of the eutectic alloy of Bi contained in said low-melting point glass and Pd of the intermediate metal.

4. An optical cap structure as set forth in claim 1, wherein said intermediate metal is a Sn-Ni alloy  
30 plated layer, so that said optical window is sealed with the cap body by means of the eutectic alloy of Bi contained in said low-melting point glass and Sn-Ni alloy of the intermediate metal.

5. An optical cap structure as set forth in claim 1, wherein said intermediate metal is a Zn-Ni alloy  
35 plated layer, so that said optical window is sealed with the cap body by means of the eutectic alloy of Bi



contained in said low-melting point glass and Zn-Ni alloy of the intermediate metal.

5       6.    An optical cap structure as set forth in claim 1, wherein said intermediate metal is a Sn-Zn alloy plated layer, so that said optical window is sealed with the cap body by means of the eutectic alloy of Bi contained in said low-melting point glass and Sn-Zn alloy of the intermediate metal.

10       7.    An optical cap structure as set forth in claim 1, wherein said low-melting point glass contains not less than 30 weight % of Bi.

15       8.    An optical cap structure as set forth in claim 1, wherein a first surface of the intermediate metal opposite to a second surface attached to the metal cap body is a rough surface, a crystal particle size of said first surface being 0.5  $\mu\text{m}$  to 1.0  $\mu\text{m}$ .

20       9.    An optical cap structure as set forth in claim 8, wherein the intermediate metal attached to the metal cap body comprises multiple plated metal layers, at least one of the metal layers having a rough surface, a crystal particle size of which being 0.5  $\mu\text{m}$  to 1.0  $\mu\text{m}$ .

25       10.   An optical device comprising:  
          a stem;  
          an optical element mounted on said stem;  
          a cap body secured on said stem to  
accommodate therein said optical element, said cap body having an opening;

30           an optical window made of glass plate sealed with said cap body to cover said opening so that an optical beam transmits through said optical window;  
and

35           a sealing member for sealing said optical window with said metal cap, said sealing member including a bismuth low-melting point glass containing no lead, an intermediate metal layer attached to said metal cap body, said intermediate metal layer being a metal capable of



eutectic reaction with respect to Bi contained in said low-melting point glass, and a eutectic alloy layer thus formed of said low-melting point glass and said intermediate metal layer.

5           11. A method of sealing an optical window, made of glass plate, with a metal cap body, having an opening, for making an optical cap structure for semiconductor device, said method comprising the following steps of:

10                 attaching an intermediate metal layer to said metal cap body, said intermediate metal layer being a metal capable of causing an eutectic reaction with respect to Bi contained in a bismuth low-melting point glass containing no lead;

15                 setting said optical window and said cap body on a jig in such a manner that a sealing member, including said low-melting point glass, is placed between said intermediate metal layer and said optical window;

20                 inserting said jig in a furnace to heat the same up to a temperature at which a eutectic reaction is caused between Bi contained in said low-melting point glass and a metal of the intermediate metal layer to seal said window with said cap body.

25           12. A sealing method as set forth in claim 11, wherein said intermediate metal attached to the cap body is a plated gold, so that an eutectic reaction is caused between Bi contained in said low-melting point glass and Au contained in said intermediate metal.

30           13. A sealing method as set forth in claim 11, wherein said intermediate metal attached to the cap body is a plated palladium, an eutectic reaction is caused between Bi contained in said low-melting point glass and Pd contained in said intermediate metal.

35           14. A sealing method as set forth in claim 11, wherein said sealing member is a ring-shaped powder tablet having a dimension corresponding to that of said opening of the metal cap body.

15. A sealing method as set forth in claim 11,



wherein said sealing member is a paste which can be coated on the optical transmission window.